

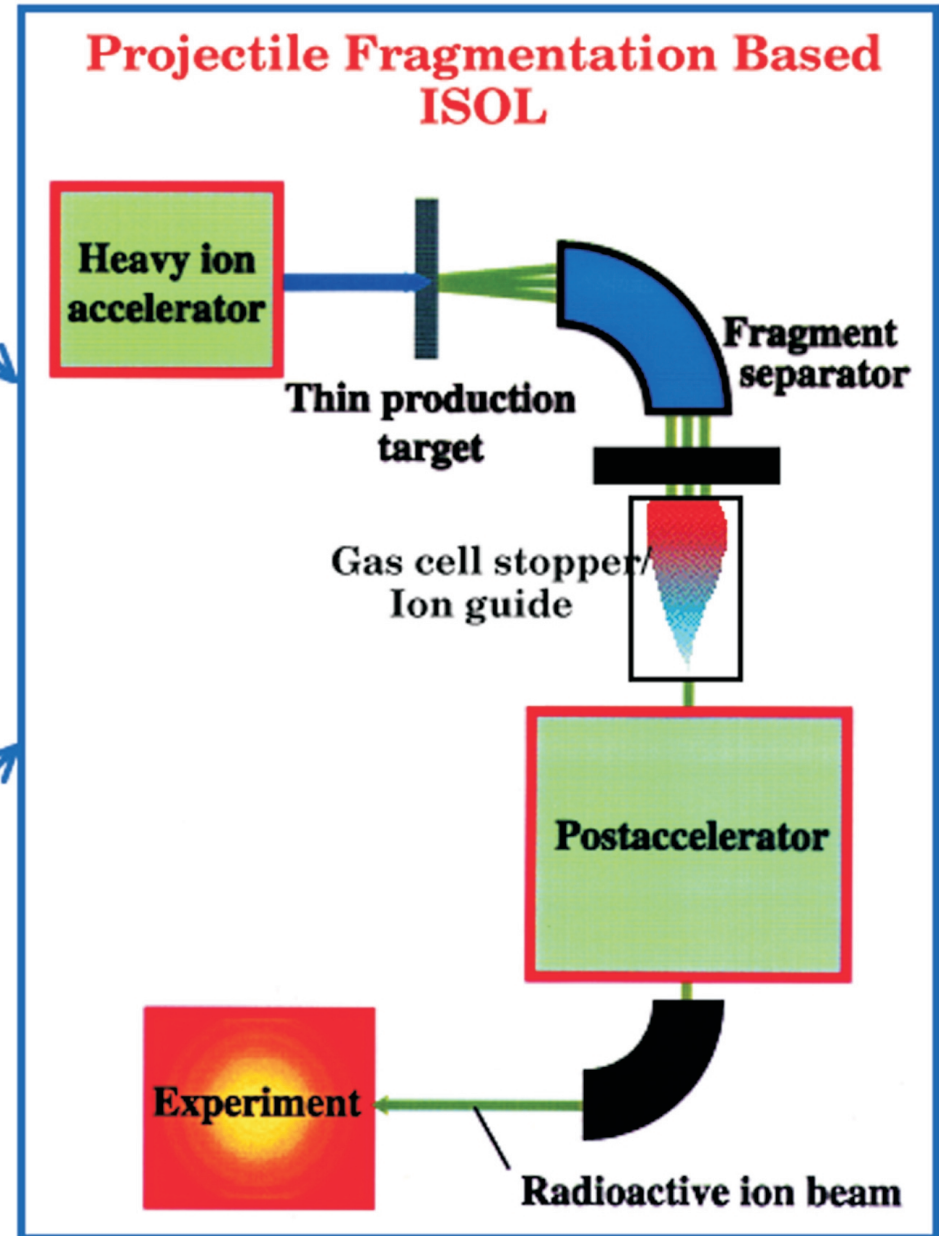
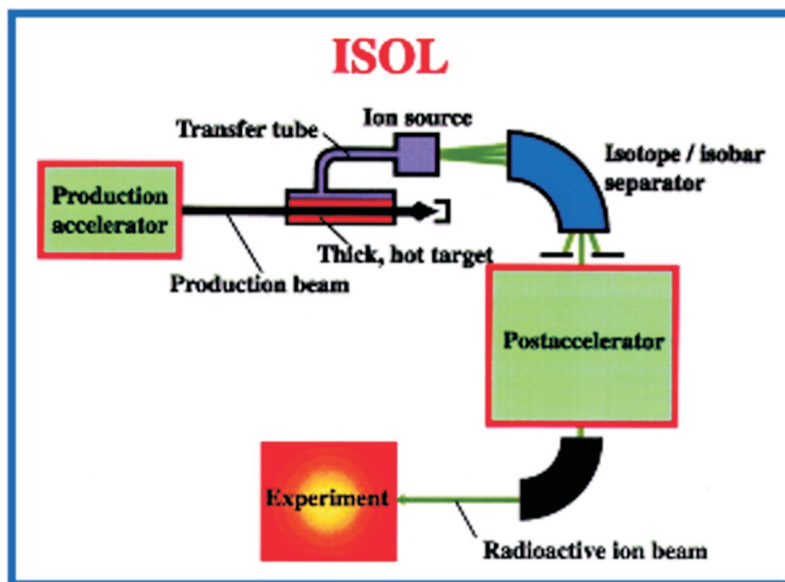
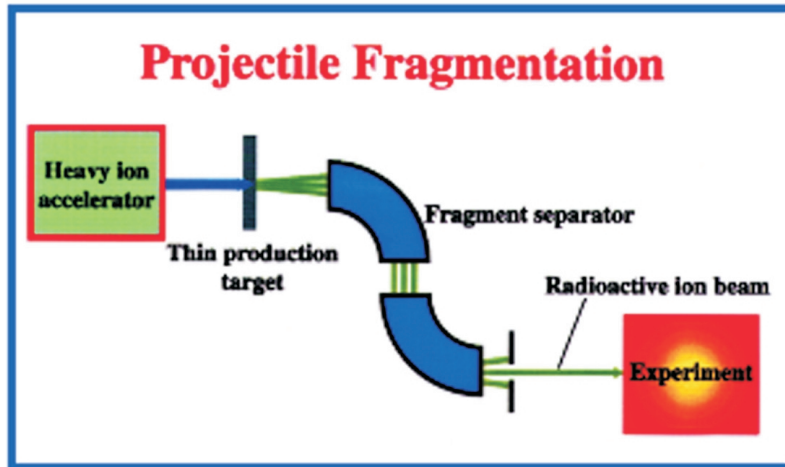
# Technical Overview of RIA

# Why is RIA Unique and New?

- 10-100x stronger uranium beams
  - Used with fast gas catcher to enable precision beams of reaccelerated rare isotopes without chemical dependence
  - World's highest intensity in-flight facility
- 8x stronger light ion beams
  - All species, e.g. 0.9-GeV protons, 2-GeV  $^3\text{He}$
- Most efficient reacceleration

**RIA comprises high intensity in-flight methods, high-intensity spallation-based ISOL, and the new fragmentation/gas catcher method**

- Fast Extraction Times ( $\sim$ msec)
- Chemical independence
- Isobar separation



# Important Technical Features of RIA

- **High power CW SC Linac Driver (1.4 GV, 400 kW)**

- Advanced ECR Ion Source

- Accelerate 2 charge states of U from ECR

- All beams: protons-uranium

- Superconducting over extended velocity range: 0.2 – 900 MeV/u

- Multiple-charge-state acceleration after strippers

- Adapted design to use both SNS cryomodules

- RF switching to multiple targets

- **Large acceptance fragment separators**

- 1) „Range Bunching“ + Fast gas catcher for ISOL

- 2) High resolution and high purity for in-flight

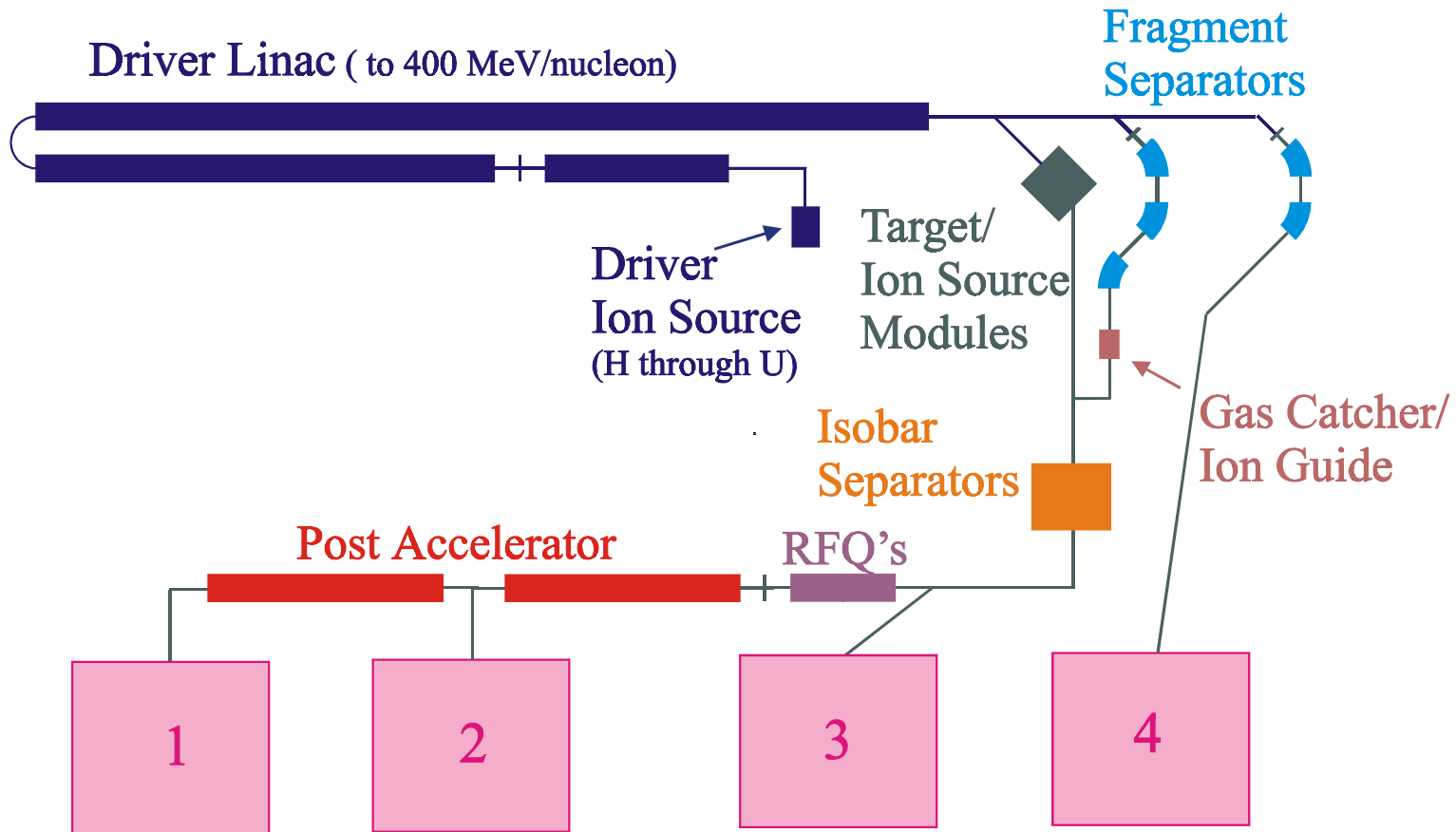
- **High power density ISOL and fragmentation targets**

- Liquid lithium as target for fragmentation and cooling for n-generator

- **Efficient post-acceleration from 1+ ion sources**

- **Next-generation instrumentation for research with rare isotopes**

# Simplified Schematic Layout of the Rare Isotope Accelerator (RIA) Facility



Experimental Areas:

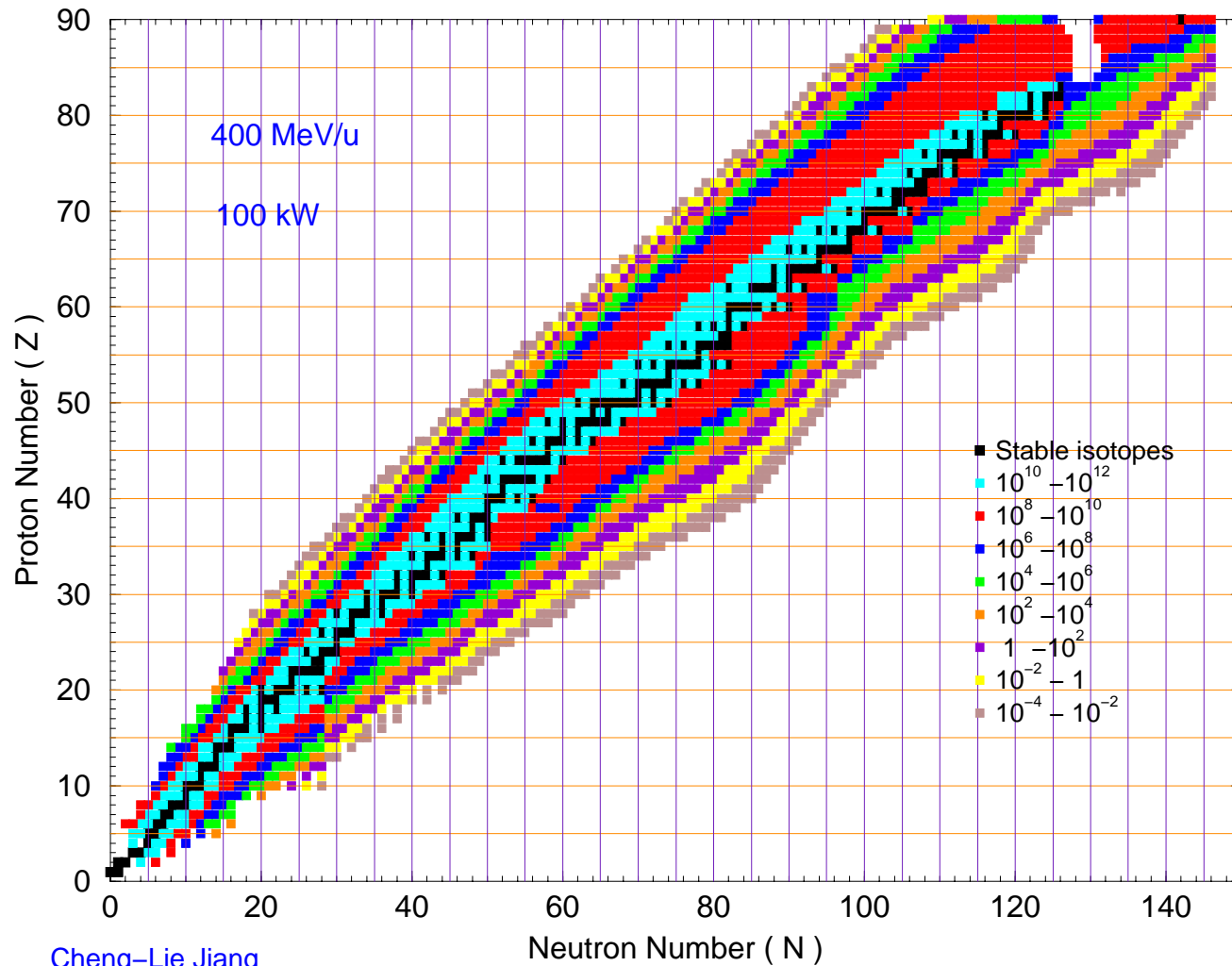
1:  $< 12$  MeV/u    2:  $< 1.5$  MeV/u    3: Nonaccelerated    4: In-flight fragments

# Outline of Talk

- Production of Rare Isotopes: Reactions
- List of Important Technologies and R&D
- Components of Multi-Beam Driver
- Target Areas and Beam Sharing
- Heavy Ion Fragment Separators
  - In-flight beams
  - Reaccelerated beams
- Spallation Target Areas
- Isobar Separation
- Components of Post Accelerator
- Experimental Areas and Instrumentation
- Conclusions

# RIA Yields of Fast Fragmentation Beams

Mass Separated Intensities (ions/s)

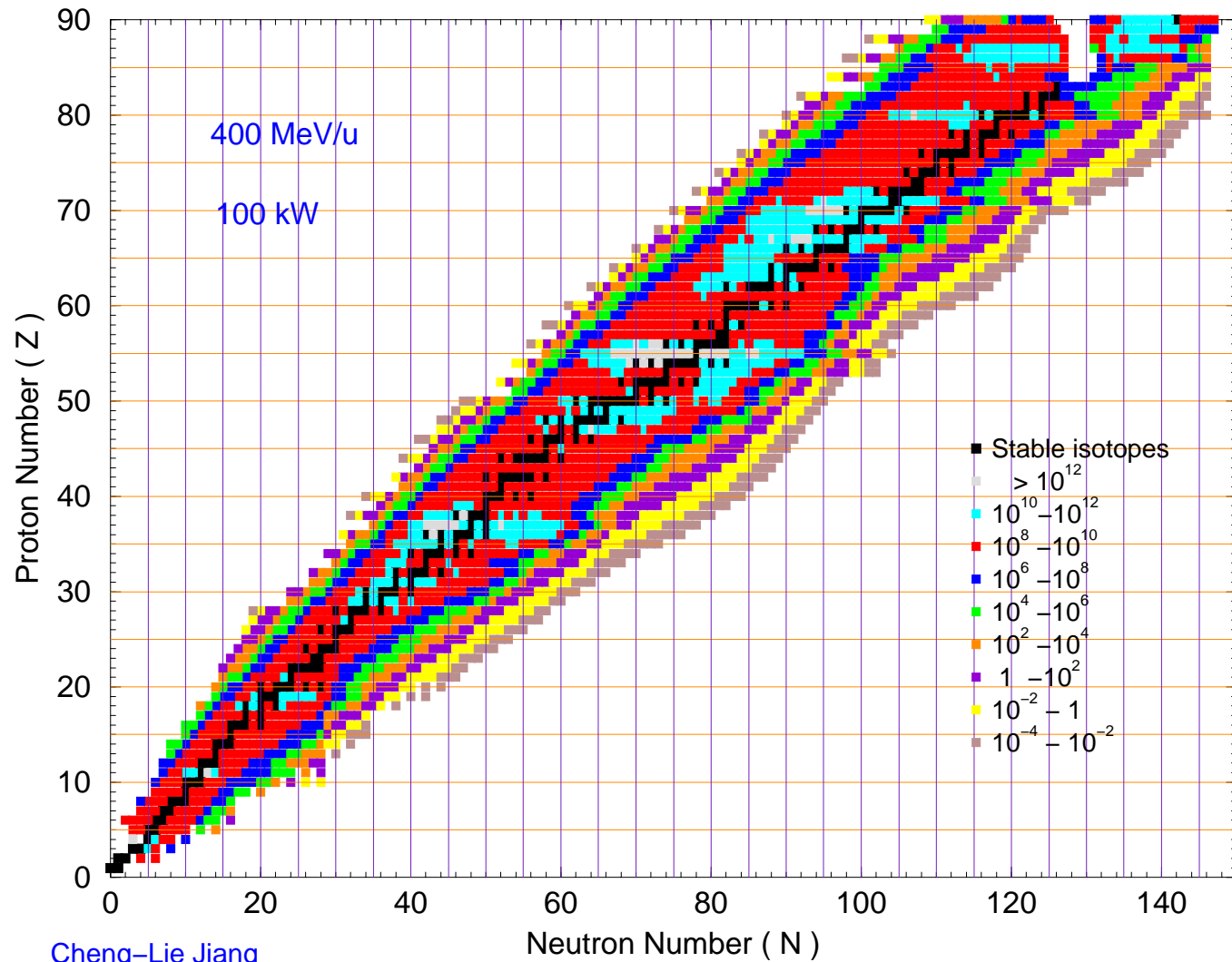


Cheng-Lie Jiang  
ANL, July 2000

yield-400f-ab.map

# RIA Yields of $1^+$ Ions for Reacceleration

Mass Separated Intensities (ions/s)

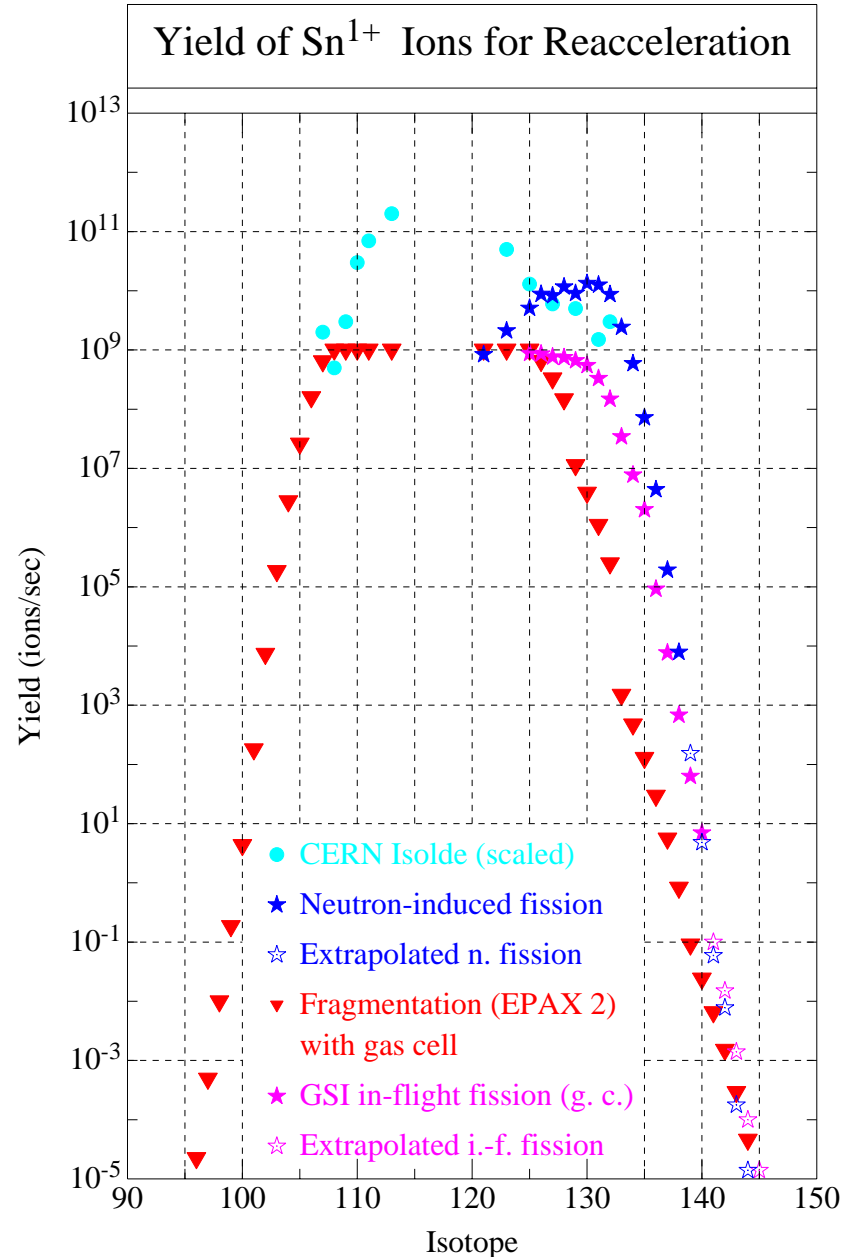


Cheng-Lie Jiang

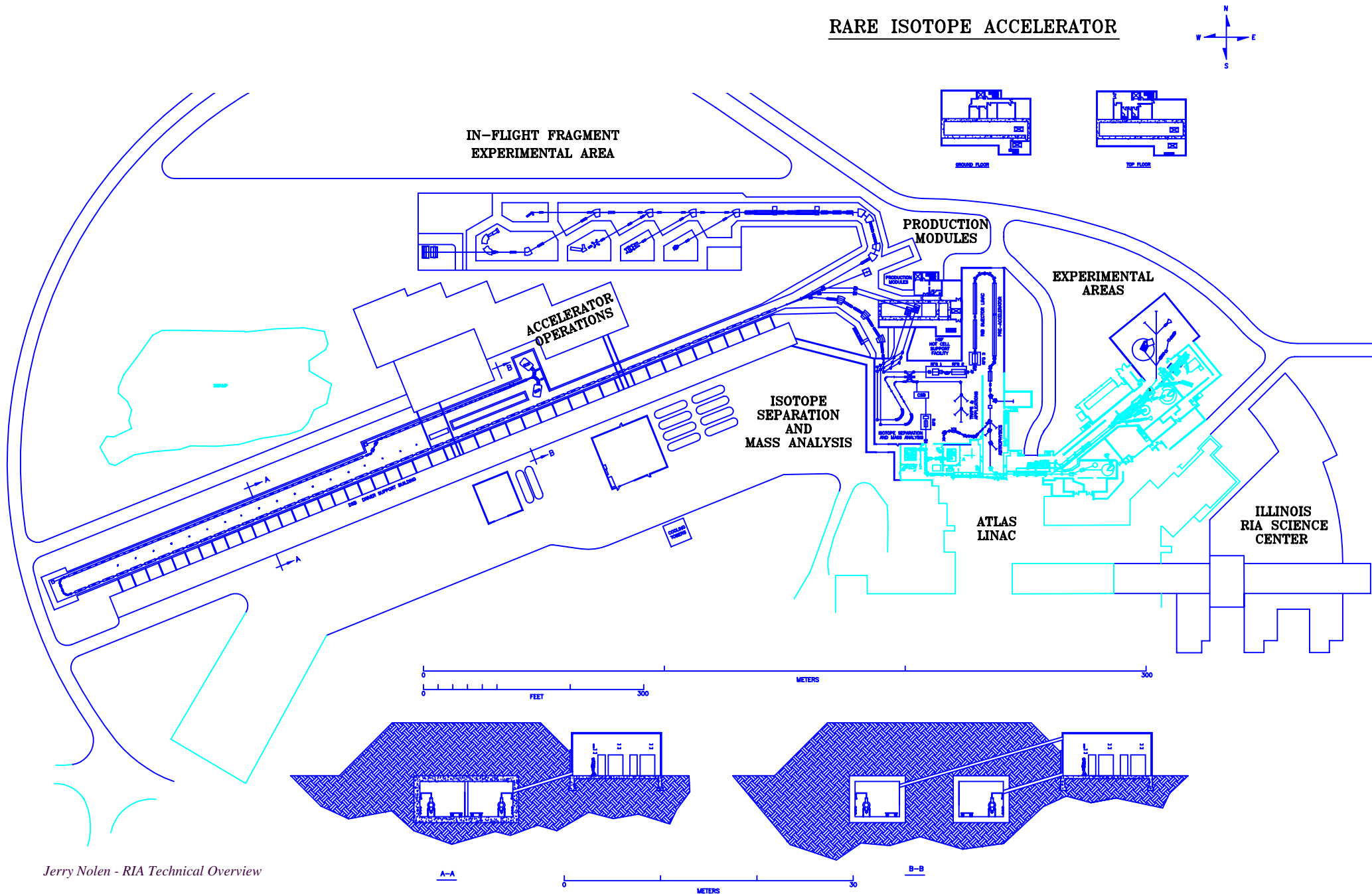
ANL, July 2000

yield-400-cb.map

To produce mass-separated  $1+$  ions at RIA several reaction mechanisms can be used. For some chemical elements the most intense beams come from the standard light-ion induced spallation or neutron-induced fission reactions. For reactive or refractory elements, or very short-lived isotopes, the heavy-ion fragmentation/gas catcher method wins. RIA is unique in its ability to utilize all of these techniques.



# Schematic Layout of RIA on the ANL Site



# Developments for RIA

## ◆ Post-Accelerator Based on ATLAS

- World's first superconducting ion accelerator

## ◆ Multi-Beam Driver

- 400 kW Superconducting Linac (protons to uranium)
- Accelerates 5 charge states after stripping
- Uses advanced ECR ion source technology
- 9 classes of SC resonators, 2 in common with SNS

## ◆ Liquid Lithium Targets

- for 100-kW heavy-ion beams (from fusion R&D)

## ◆ Two-step Target Concept

- neutron-generator ( $d+W > n+U$ )

## ◆ Fast Gas Catcher

- short release times,
- chemical independence,
- no ion source

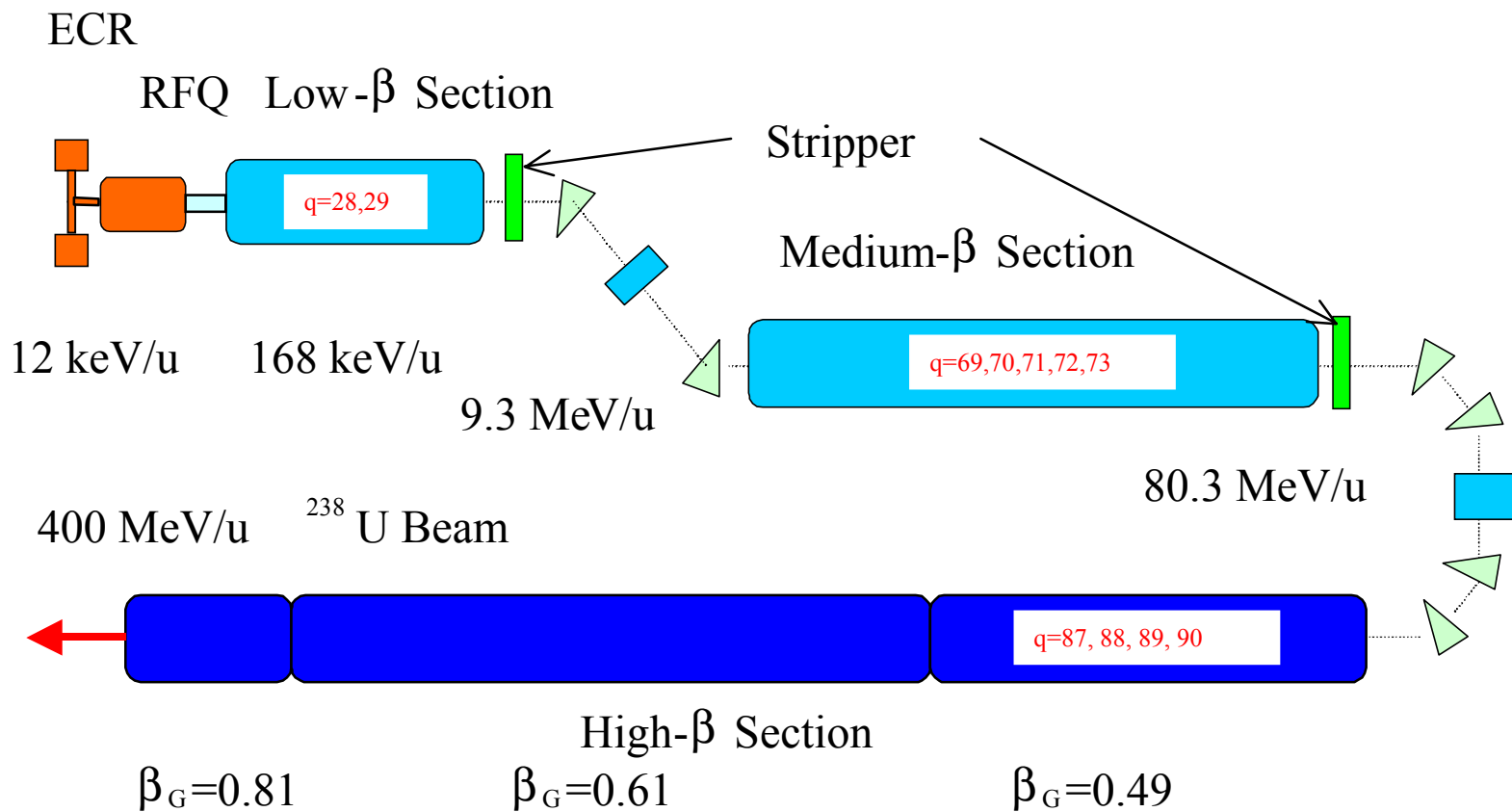
## ◆ CW 1+ RFQ

- high-quality, efficient post accelerator

## ◆ $1+ \rightarrow 2+$ stripping

- efficient stripping at very low velocity in helium gas

# Block diagram of Driver

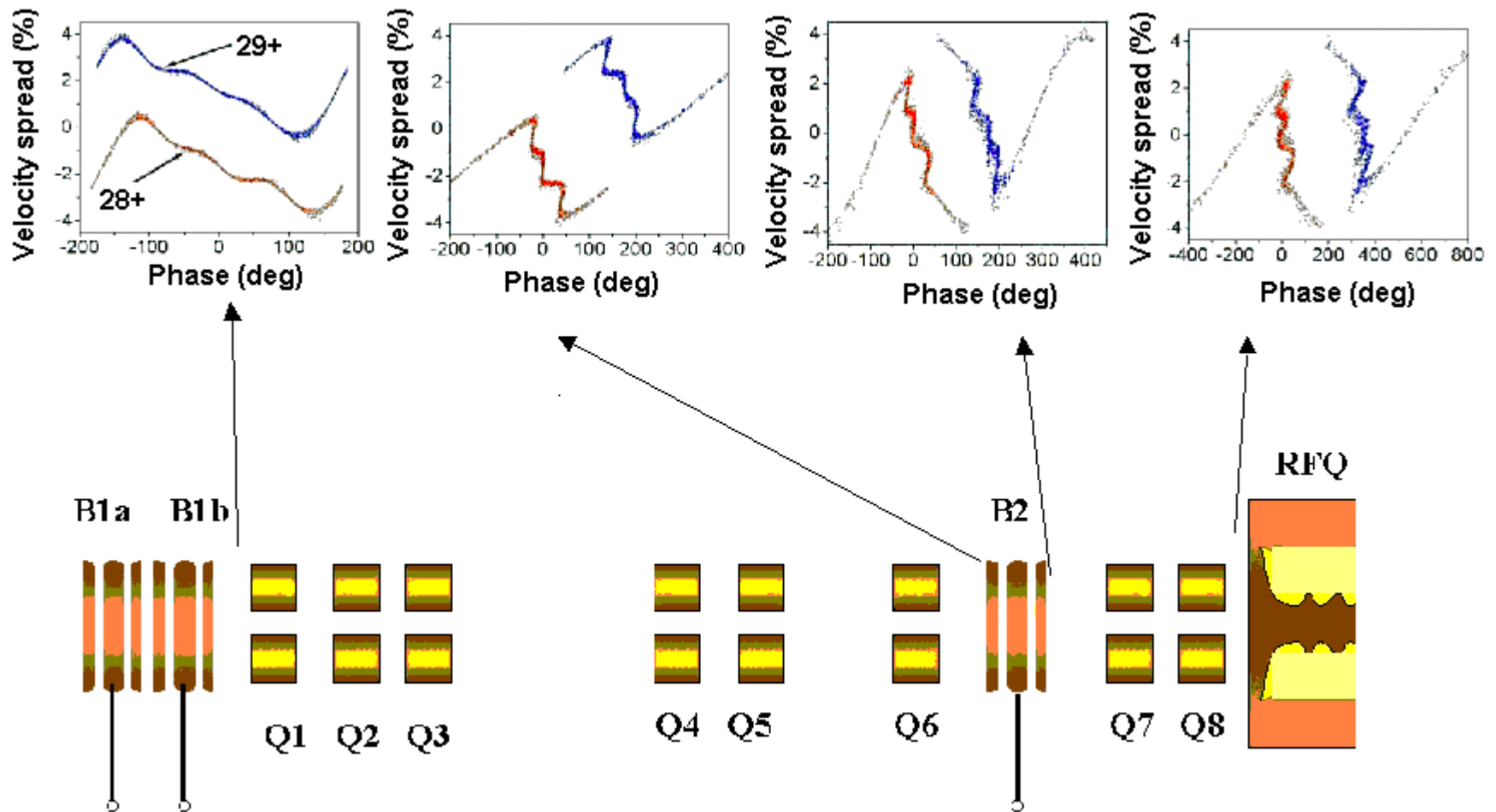


# Beam list for Driver

<b>A</b>	<b>I source</b>	<b>Qinj</b>	<b>Qstrip</b>	<b>Qout</b>	<b>I out</b>	<b>Energy out</b>	<b>Beam Power</b>
	pμA				pμA	MeV/u	kW
1	556	1	-	1	445	899	400
3	232	2	-	2	186	717	400
2	416	1	-	1	333	600	400
18	54	6	8	8	40.3	551	400
40	29	8	18	18	18.0	554	400
86	15	14	33-34	36	8.8	515	390
136	12	18	46-48	53-54	6.2	476	400
238	3	28-29	69-73	87-90	1.6	403	152

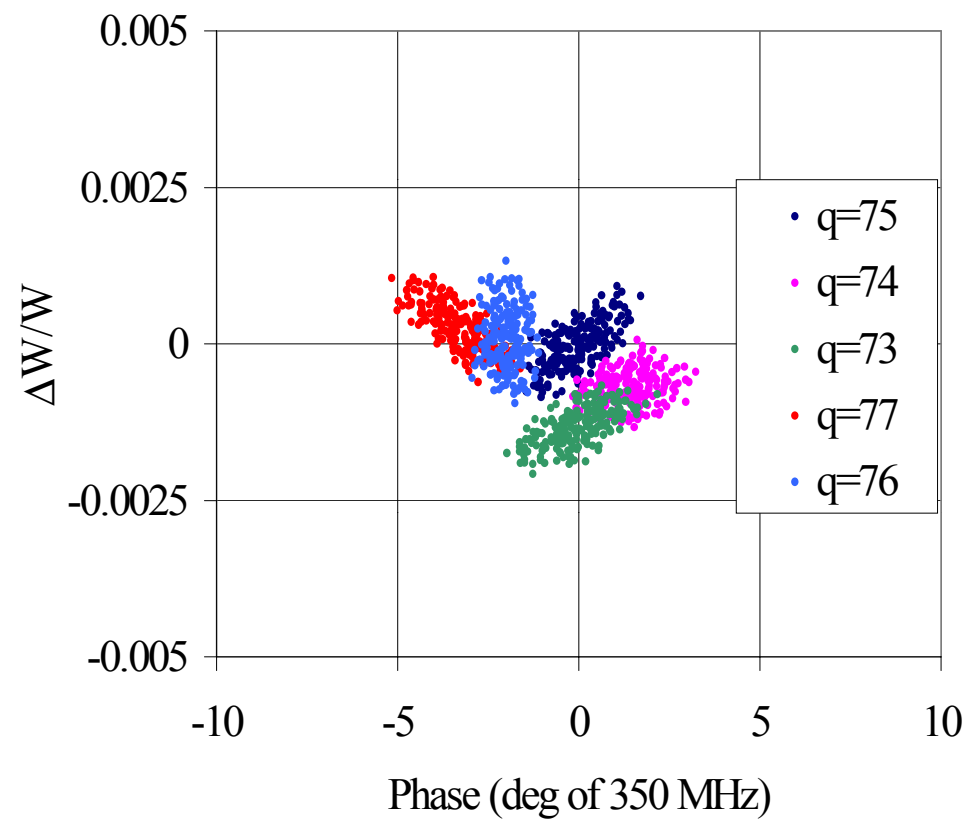
RF power limits beam to 400 kW; the heaviest beams are limited by ion source output at the required charge state

# Longitudinal phase space plots of two-charge state uranium beam along the LEBT



Due to synchrotron oscillations the energy spread is much less than the charge difference.

Phase space plots of a five charge-state uranium beam at 85 MeV/u before passing through the second stripper.



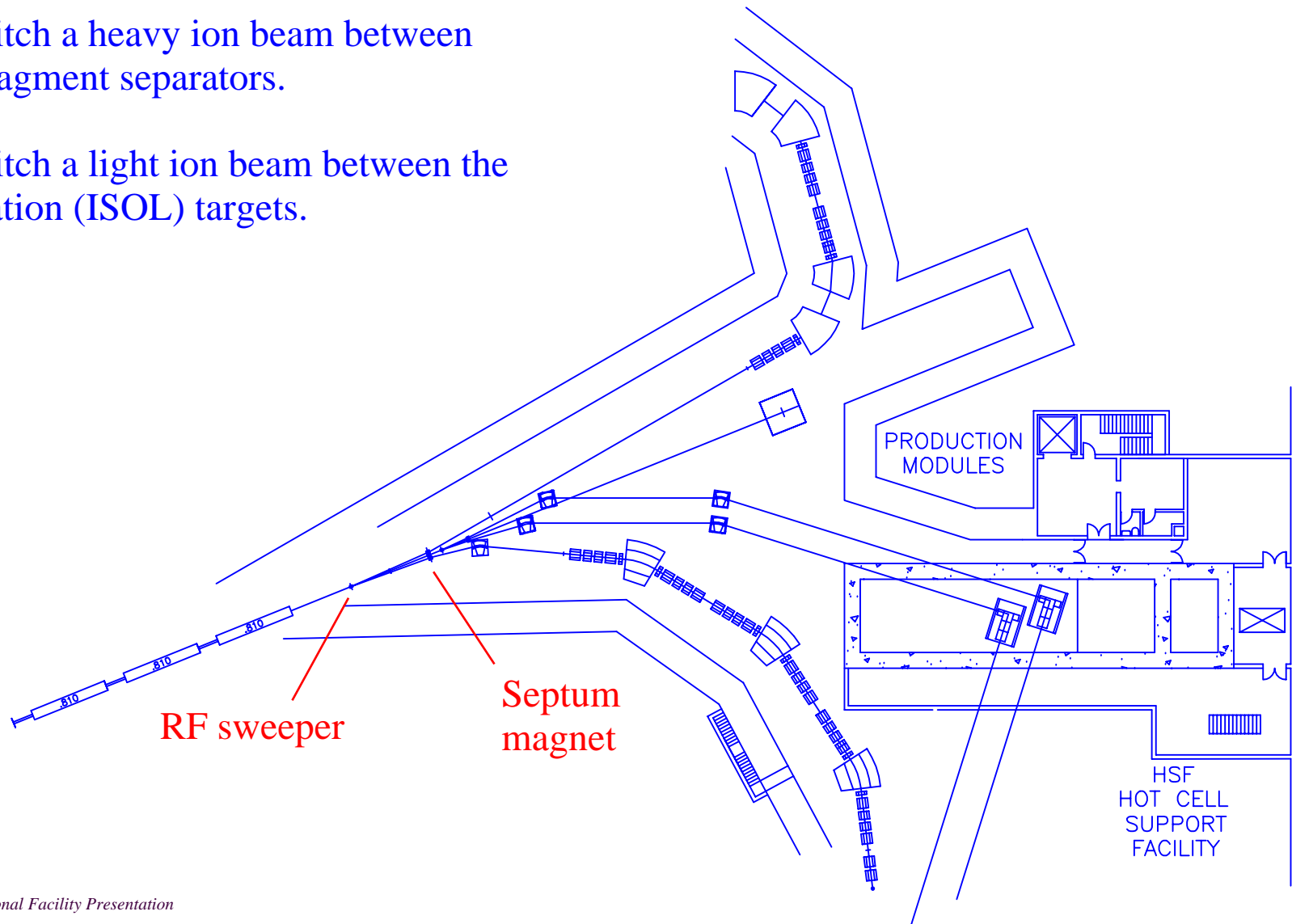
# 9 types of SC resonators

- Six drift-tube types:
  - Covering  $\beta = 0.02$  to  $0.38$ .
  - Prototyping of mid-  $\beta$  types is in progress
- Three elliptical types:
  - Covering  $b = 0.49$  to  $0.81$ .
  - Two are identical to SNS resonators.

# RIA Driver Switchyard for Beam Sharing to Production Targets

## Beam Sharing Modes:

1. RF switch a heavy ion beam between the two fragment separators.
2. RF switch a light ion beam between the two spallation (ISOL) targets.

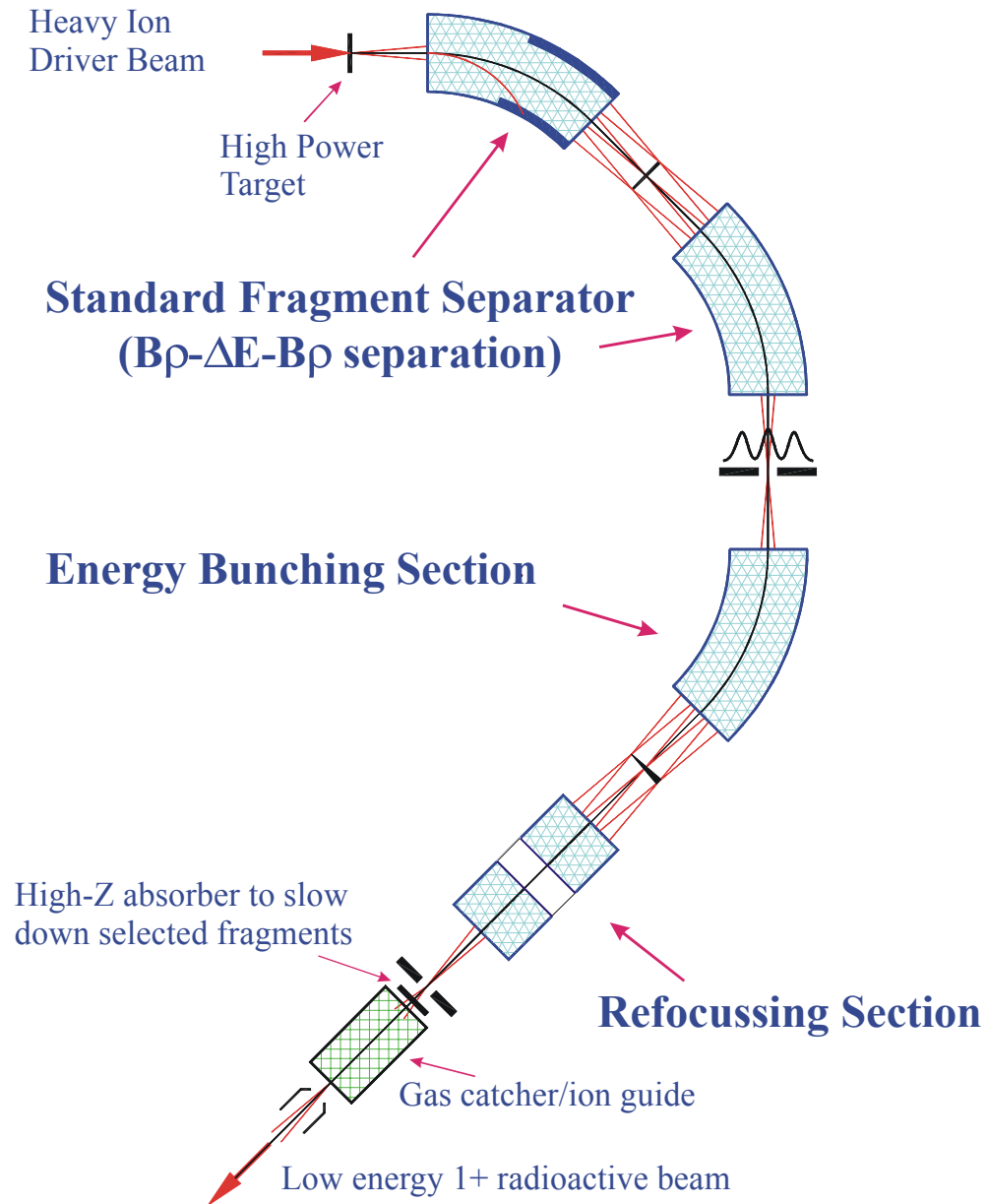


# RIA will use 2 types of Fragment Separator

## **Broad range, energy bunching**      **High resolution/high purity**

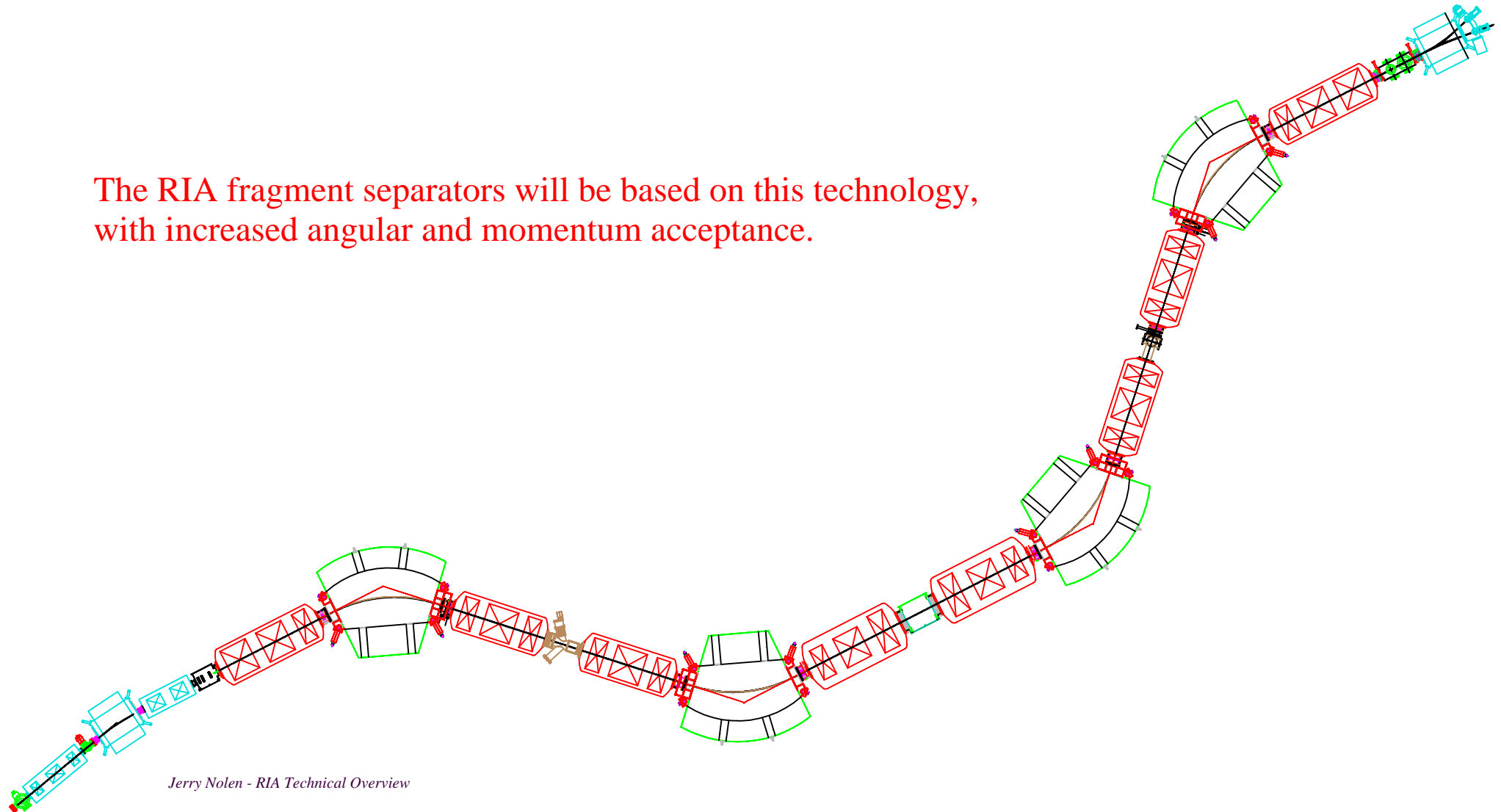
- 18% momentum range
  - 10 msr solid angle
  - 0.1 % momentum resolution
  - Energy spread compensation stage to minimize range straggling in helium gas
- 6% momentum range
  - 10 msr solid angle
  - 0.03 % momentum resolution
  - Wien filter stage for isobaric purification

## Schematic Layout of Fragment Separator and Gas Catcher

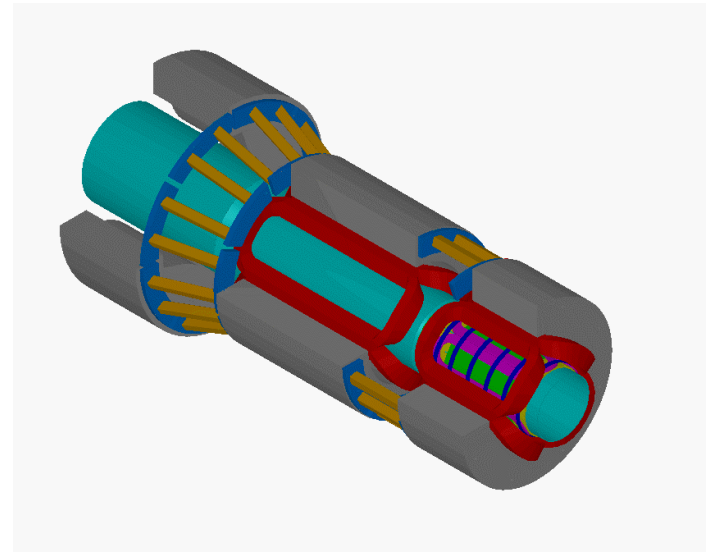
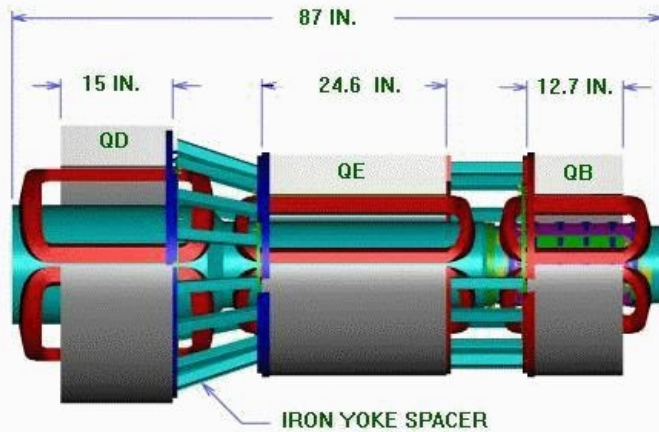


# Mechanical Layout of the A1900 Fragment Separator at NSCL for the Coupled Cyclotron Project

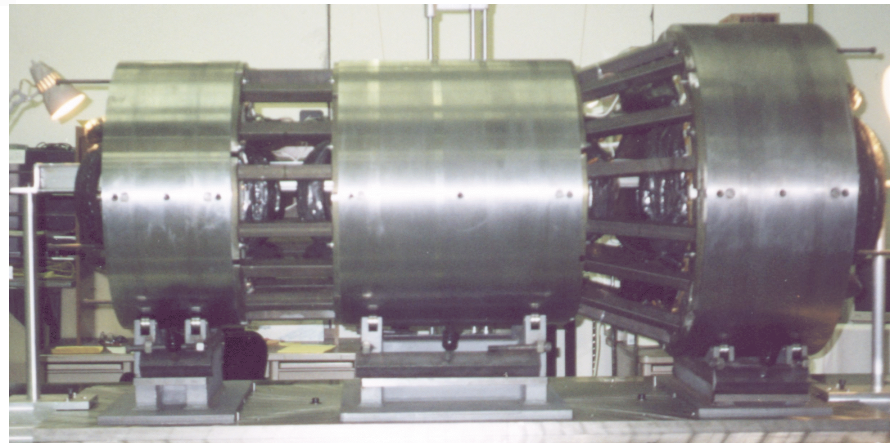
The RIA fragment separators will be based on this technology, with increased angular and momentum acceptance.



# A1900 Quads

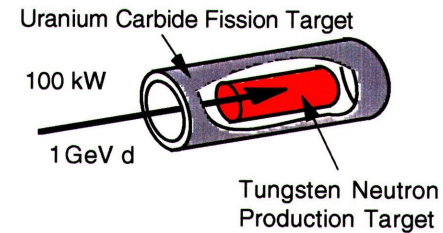


Large aperture  
superconducting triplets  
recently constructed at NSCL  
for the Coupled Cyclotron  
Project

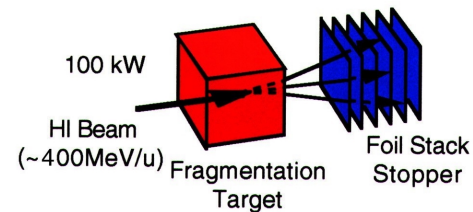


A wide variety of production mechanisms and target concepts will be used at RIA to produce rare isotopes with 100-kW beam power.

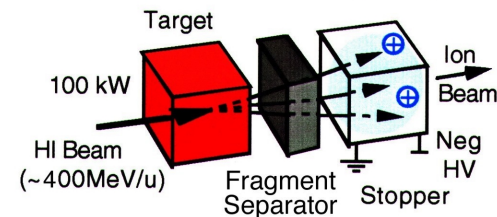
### 2-Step Fast Neutron Fission



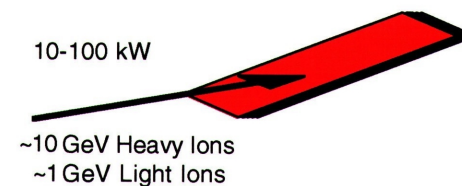
### 2-Step Projectile Fragmentation (Solid Stopper)



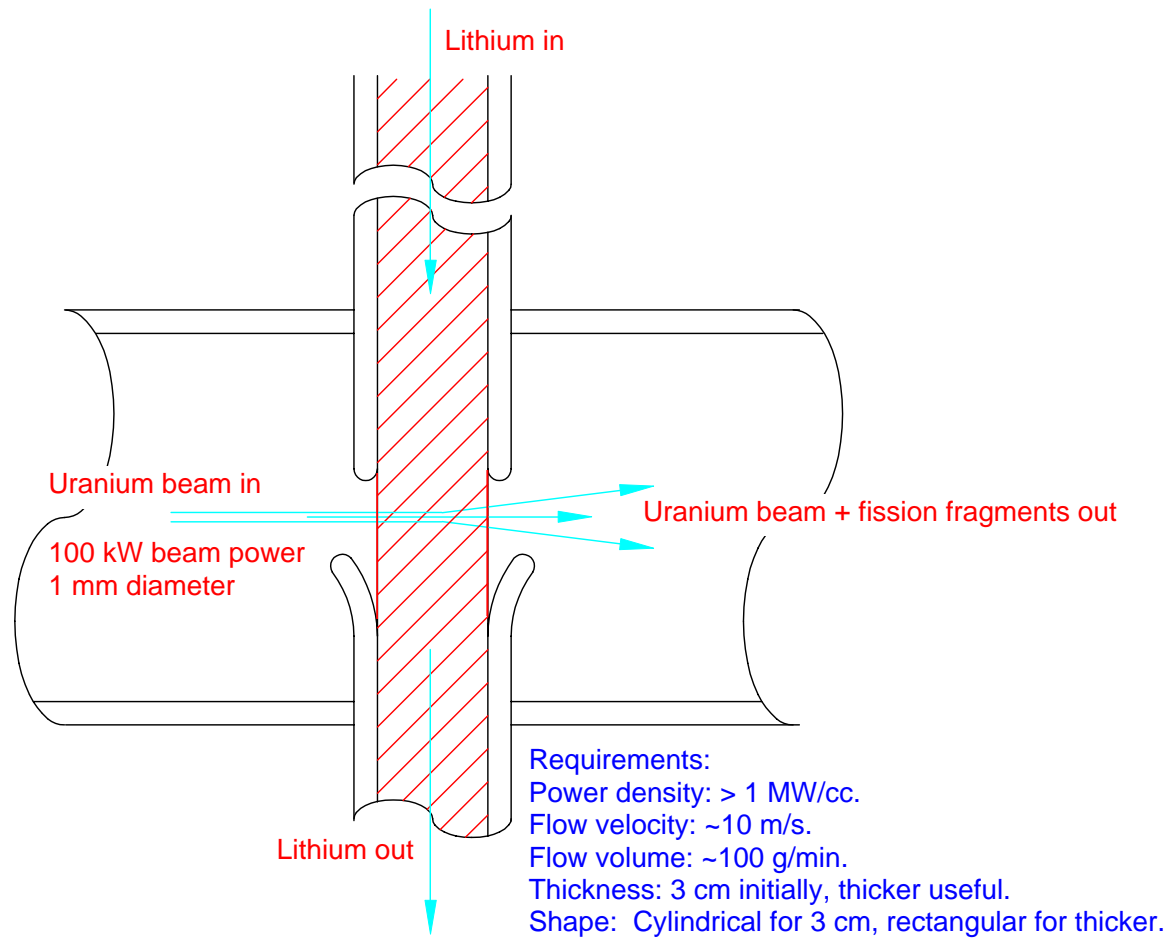
### 2-Step Projectile Fragmentation (High Pressure He Gas Stopper Cell)



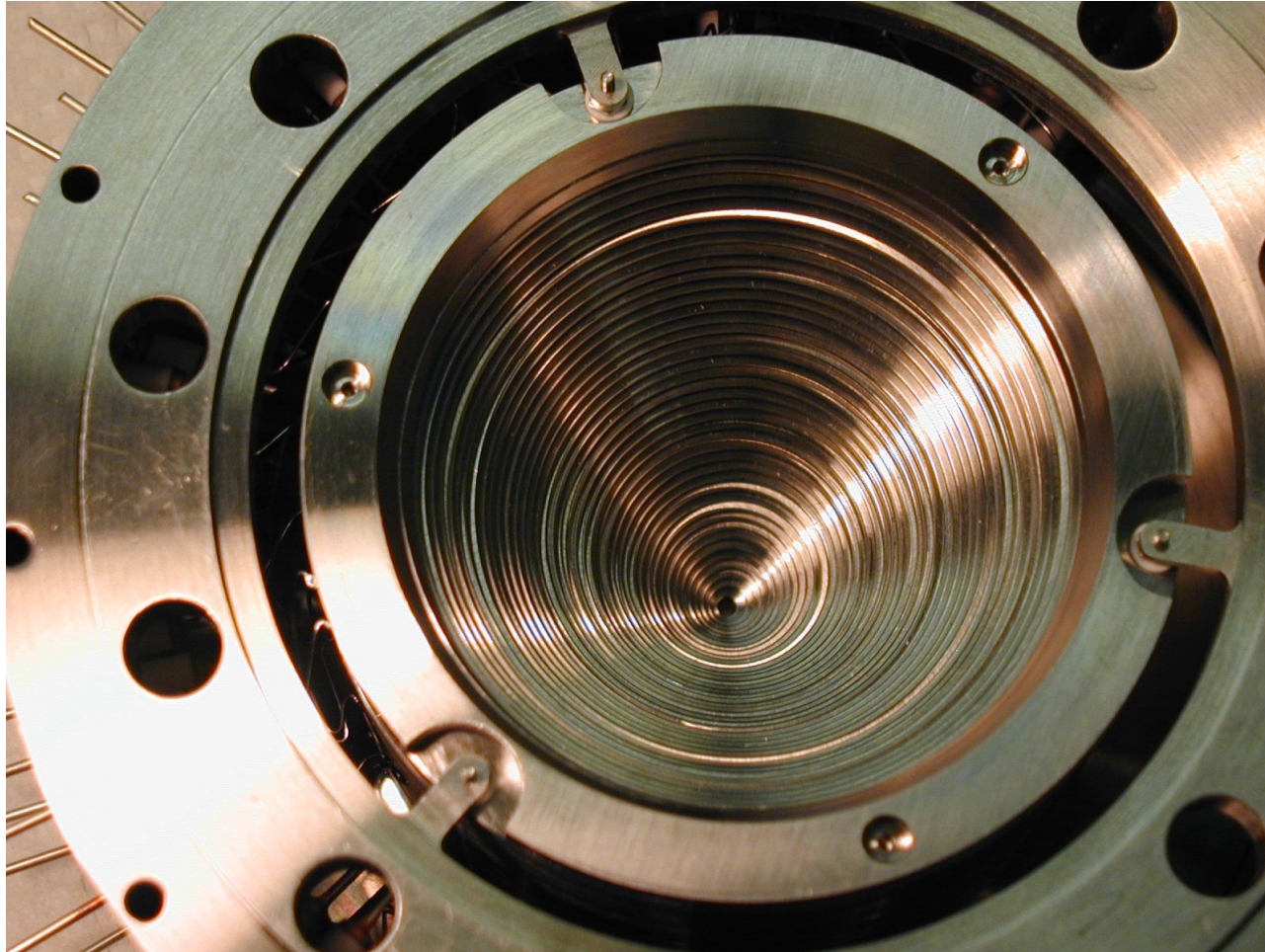
### One-Step Spallation Target



## Concept for 3 cm thick windowless flowing liquid lithium target

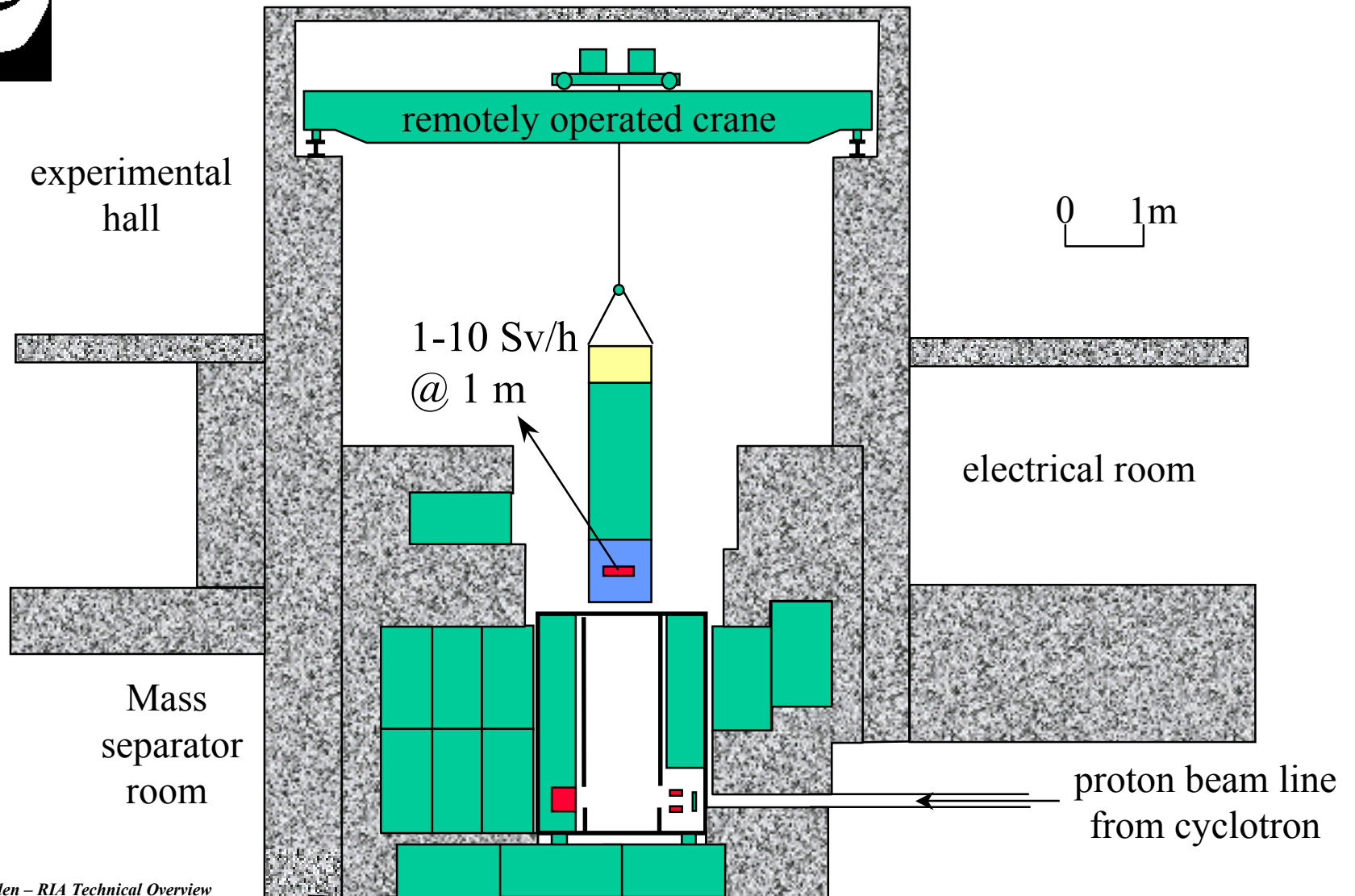


## Photo of the Electrodes Near the Extraction Aperture of a Prototype Fast Gas catcher

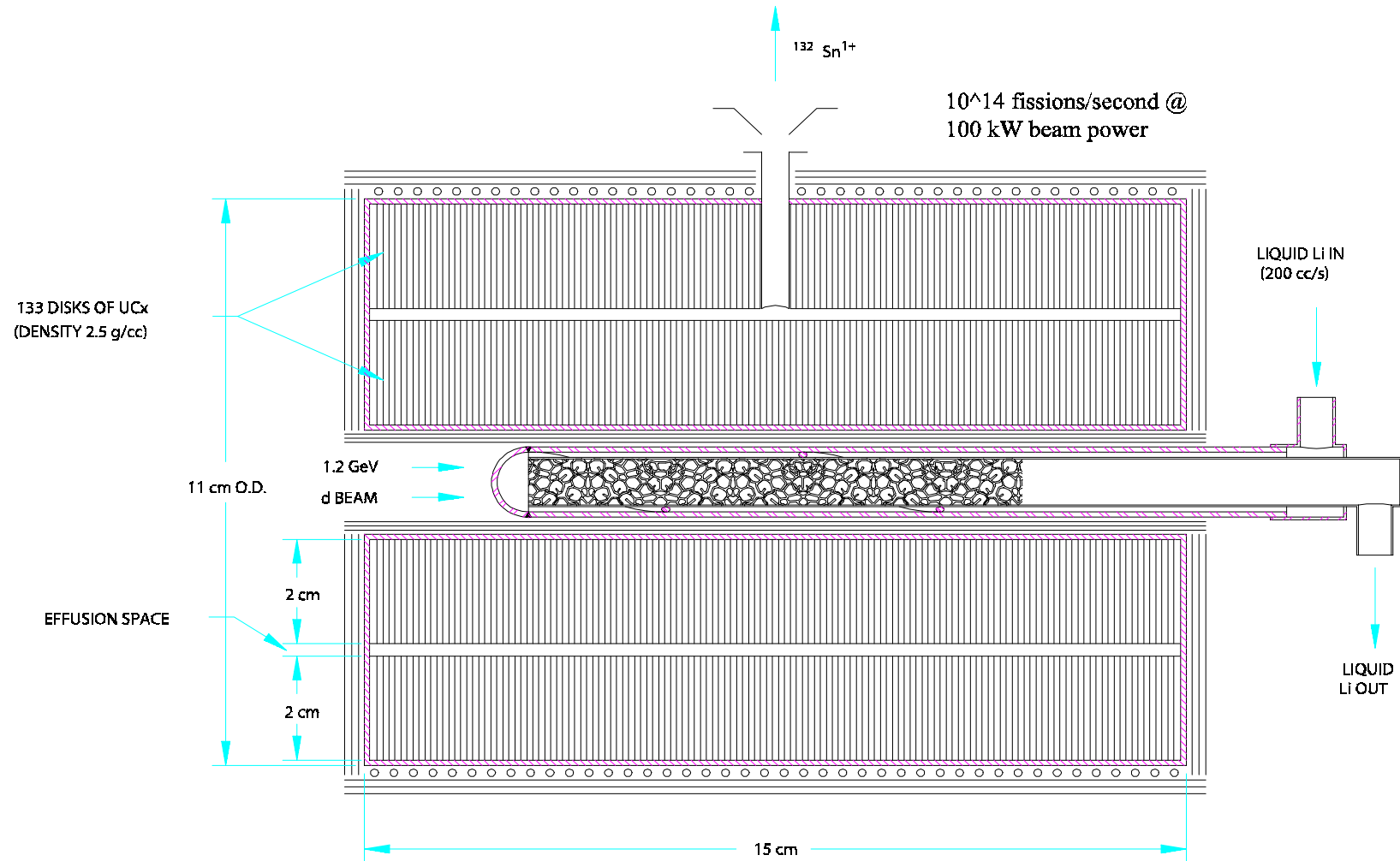




# ISAC target servicing:



# Two-step, neutron-generator target geometry

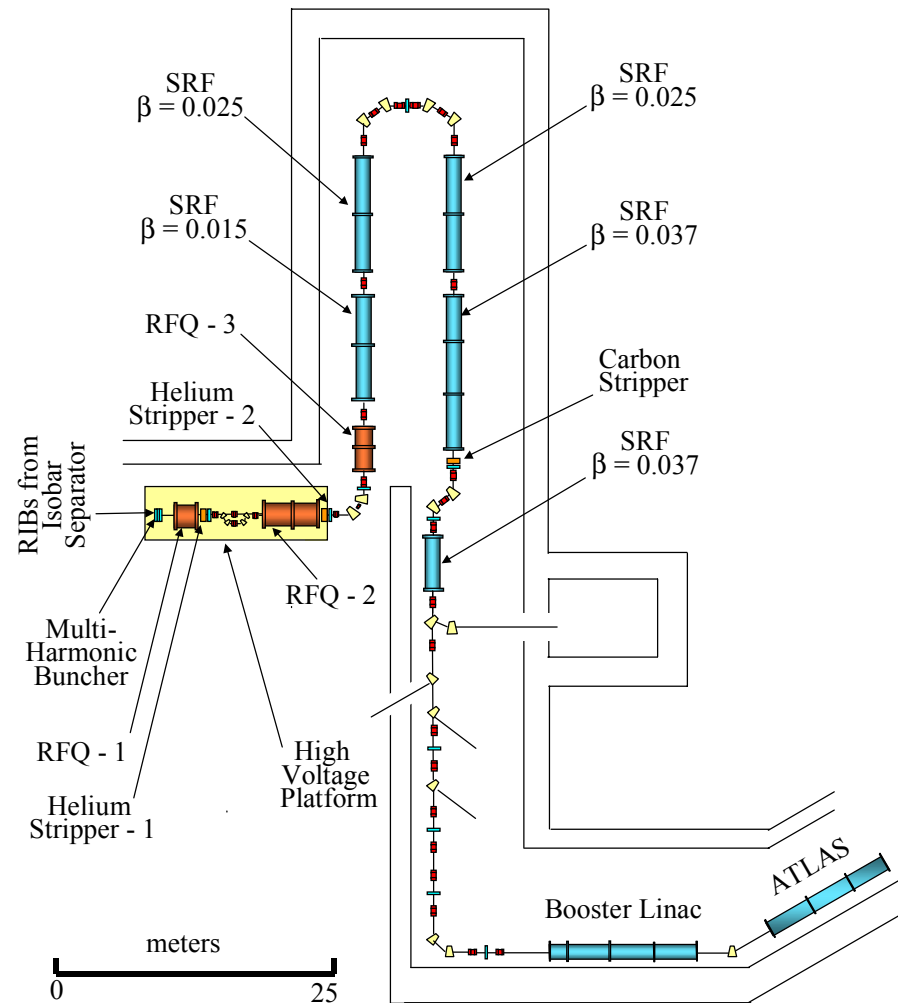


LIQUID-LITHIUM COOLED TUNGSTEN TARGET/ION SOURCE

## F



# Layout of low q/m RIB linac injector



# Summary

- RIA brings together a powerful, unique combination of advanced technologies to make possible a premier facility for nuclear science.
- Use of proven technologies together with simulations, engineering studies, and prototyping indicate that there are no show-stoppers and we are ready to build RIA.
- Ongoing development and prototyping of RIA components as currently coordinated by a national committee must continue.